UNDERSTANDING RADIATION, NORM AND TENORM

Kurt Rhea
General Manager, NORM Services

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Serving the U.S and Canada

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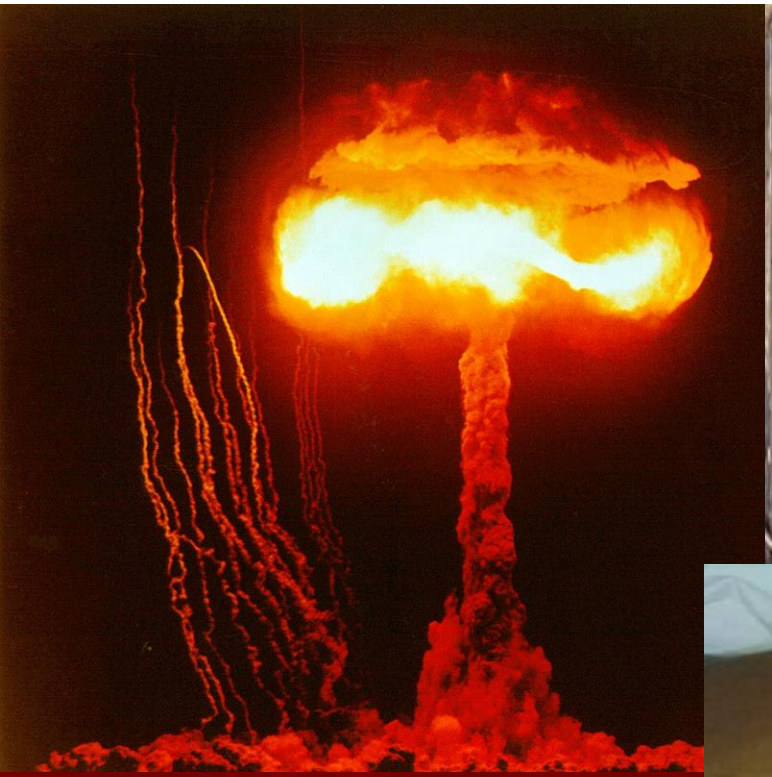
- Licensed radioactive materials management – NORM/TENORM
- Surveys, Sampling, and Characterization
- On-site Remediation & Reclamation
- Decontamination
- Demolition & Decommissioning
- On-Site Containment
- Packaging, Transport & Disposal
- Regulatory Consulting/Assistance
- Radiation Training, Safety & Protection Programs

What comes to mind when one thinks about radiation?



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NORM – A Lighting Rod for Industry and Landfills

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The “R” Word - Radiation

- The fear of the unknown
- Can’t see it, feel it, smell it, or taste it
- Radionuclides are present throughout our environment
  Radium, Uranium, Radon, Lead, Thorium, etc.
- Naturally occurring

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Definitions & Terms

- NORM - *Naturally Occurring Radioactive Materials*
- TENORM - *Technologically-Enhanced NORM*

  Radionuclide concentrations increased by or as a result of past or present human practices

- Why the distinction?
- Picocurie (pCi/g)

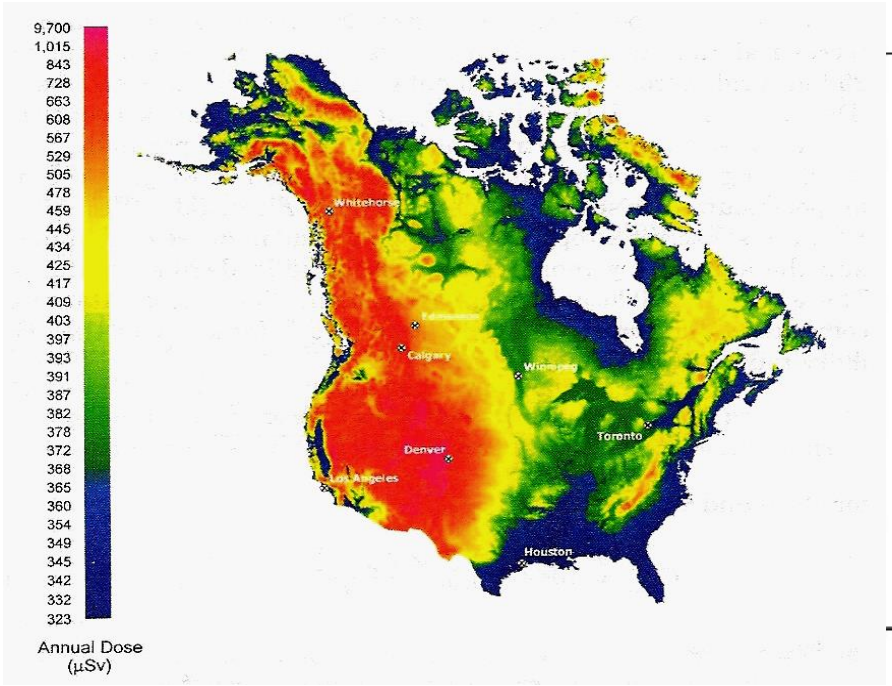
Where is Radiation Found?

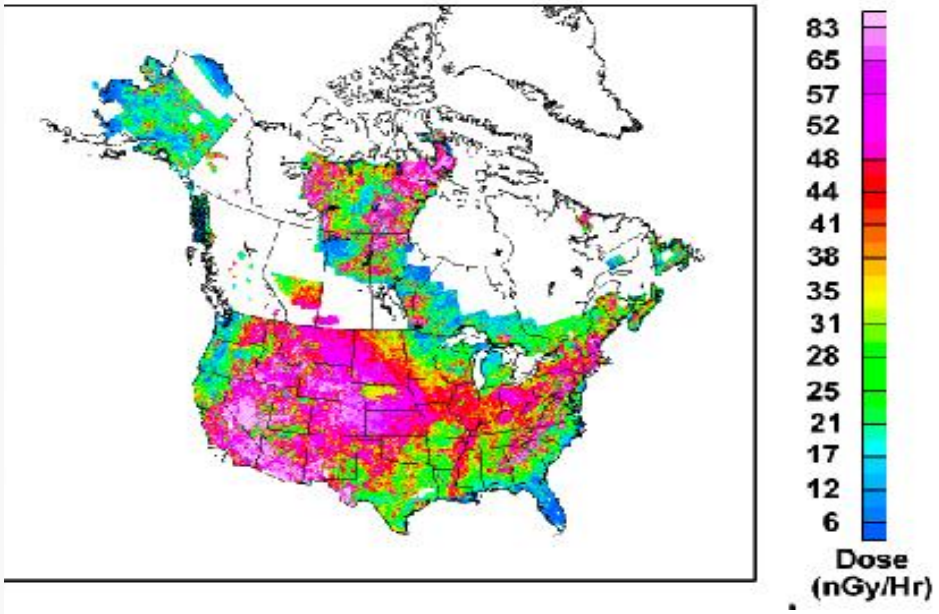
- Cosmic
- Terrestrial
- Radon/Thoron Gases
- Medical – x-rays, dyes, radiation treatment
- Industrial Sources
  Building materials, processing, filtering, tracers, irradiation equipment
- Other Sources – food, smoking

Natural Background Radiation - a Few Facts

- We live in a radioactive environment
- We are continuously bombarded with radiation energy from space and from the earth's surface
- We take in radioactive materials with the air we breath, the water we drink, and the food we eat
- Our bodies contain radioactive materials
- Our biosphere is powered by nuclear fusion reactions
- Our earth and weather are respectively shaped by radioactivity and radiation from space – volcanos!
- It has always been that way!

Cosmic Ray and Terrestrial Background Varies Considerably Across US





National Council on Radiation Protection and Measurements; NCRP Report No. 160, "Ionizing Radiation Exposure of the Population of the United States", 2006

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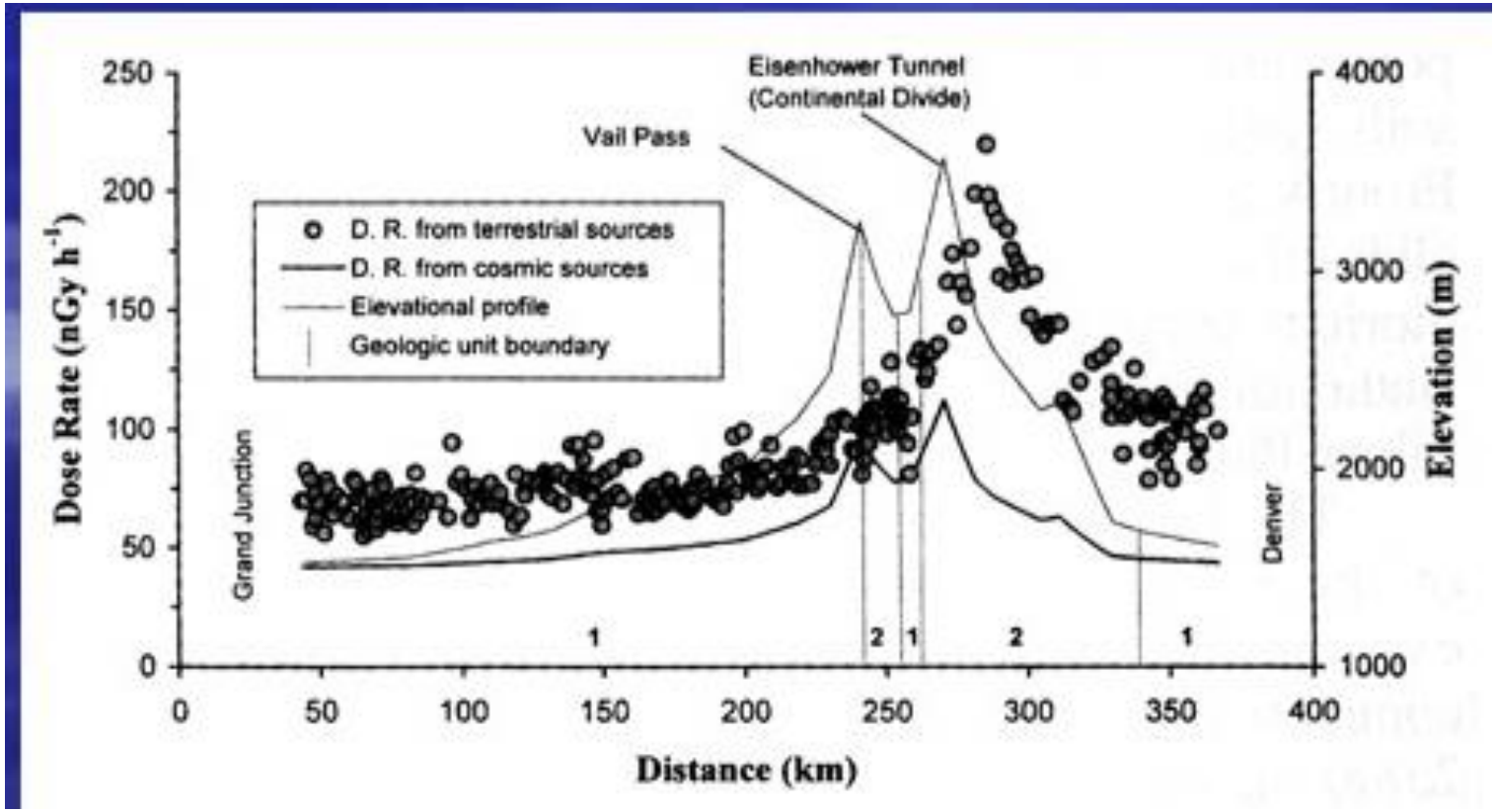
Variations in Natural Background Radiation in Colorado Across Interstate 70



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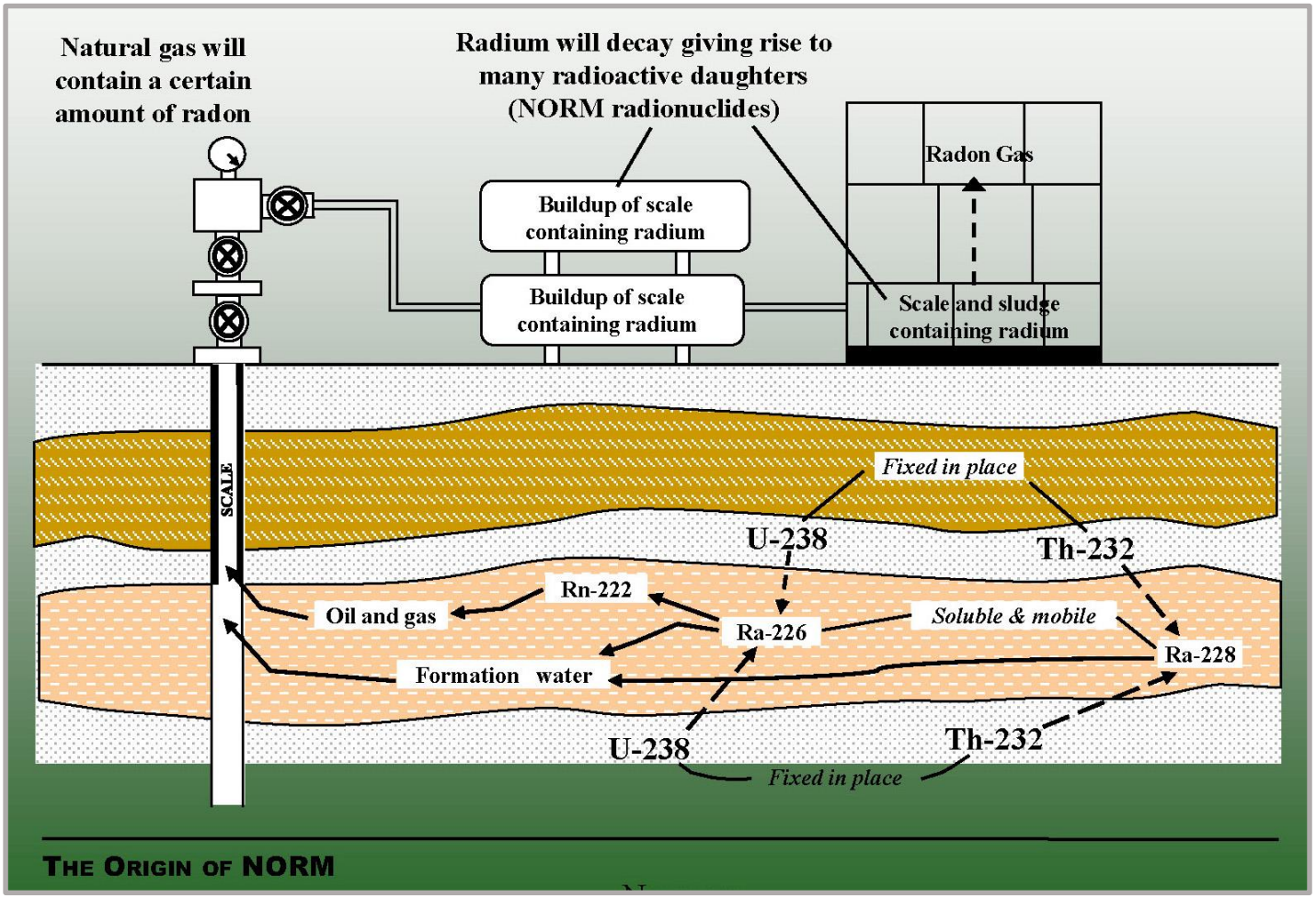
How is TENORM Generated?



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The Public, Regulators, and Employees

- States That Have Seen Very Public TENORM Issues
  - North Dakota
  - West Virginia/Ohio/Pennsylvania/New York
  - Louisiana
  - Colorado – water treatment plant

- Challenges
  - Misinformed & Misconceptions
    - Activists & Community Organizers – purposeful in misinforming
    - Employee Fears
    - Just as Inflammatory as Pipelines, Spills, or Gas Emissions
  - Allowing Disposal or Raising Disposal Limits Is Difficult
  - Not In My Backyard

High Profile Cleanups

Cleanup underway in Noonan

12 HOURS AGO • BY LAUREN DONOVAN | BISMARCK TRIBUNE

NOONAN — A radiation team cleaning up an illegal oil field waste dump site in Noonan found an underground cache of the material and labels that are possible evidence of companies that contributed to the mess.

The cleanup was expected to take all day Wednesday, with a crew of six workers in oil-streaked suits and respirators pulling tons of low-level radioactive filter socks from an abandoned gas station in this tiny town near the Canadian border.

The dump was discovered in late February and state and local officials started looking for the culprit and making plans to get the material safely disposed.

The property owner is a criminal fugitive in Wyoming and the state is using its own clean up funds instead of forcing the owner to deal with the situation.

Robert Krumberger, manager for Secure Energy Services, said his workers soon uncovered an underground sump area in the old garage, which also was full of the filter socks. He said he called for additional lined containers and estimated the building contained 60 cubic yards of filter sock waste, instead of the 40 originally estimated.

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What Are The Issues To Be Considered?

1) Worker Safety
2) Environmental Protection
3) Potential Liability of Generators
4) Public Safety, but mostly **Perception**
5) Regulations & Compliance

Where Do We Find TENORM?

TENORM can be found in the following industrial activities:

- Mining/Ore Processing
- Metal Recycling
- Forest Product Combustion
- Thermal Electric Production
- Fertilizer Production
- ***Pet Food – Really?***
- Ceramics
- Municipal Water Treatment
- Oil & Gas Production

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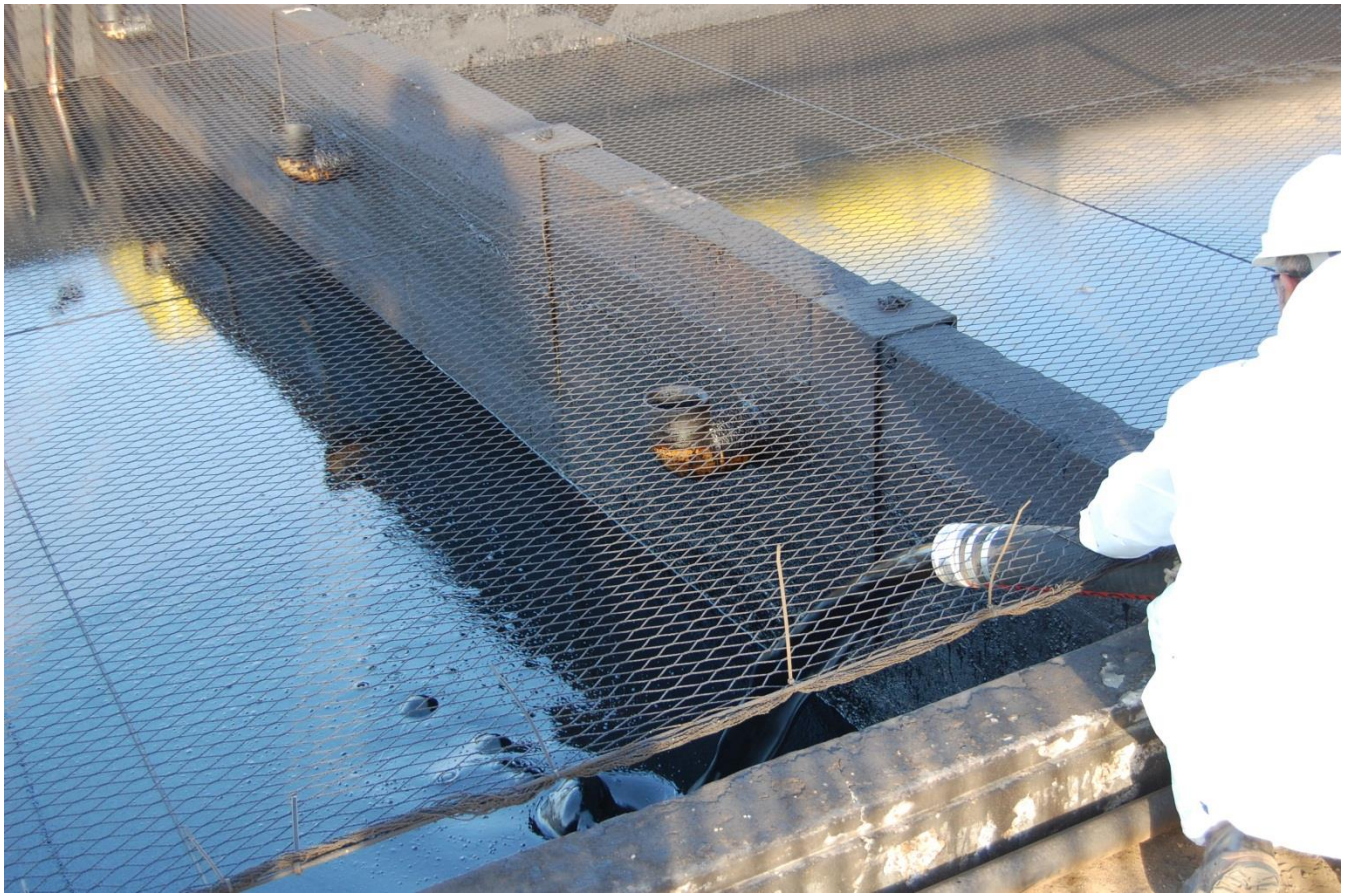
Clarifying Ponds and Tanks



Flowback & Produced Water

Radioactive Tails from Mega Ponds

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Mega Ponds in Canada

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Filters and Screens

Taming the Wild West (North Dakota)

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Filter Socks: Radium-226, -228 and Lead-210

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Bottom Hole Pumps

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Scale from Produced Water: Radium-226 and-228

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Stockpiles of Impacted Tubing

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Tanks, Tank Bottoms, Lubricants, and Pipe Scale

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Tank Bottoms

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Heater Treaters and Fire Tubes

Dealing with the Unexpected

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Impacted Containment Floor & Debris

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Floor View – NORM and Brine Impact

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Systematic Extraction of Impacted Floor

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Demolition & Impacted Debris/Soils

Many issues are at saltwater disposals:

North Dakota: 500+
Colorado: 12

Production Water Spill Fills Moat

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Form Will Fool You

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Levels Vary Dramatically *(most are very low)*

- Geology/Geography
- Processes & Equipment
- Time in Service

Pipeline Inspection Tools: Pb-210

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Pb-210 TENORM Contaminated Vessels

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NORM Activity Levels

- NORM Unrestricted Release @ 8 pCi/g
  - Treater Waste: ≈ 16,200 pCi/g
  - LPG Waste: ≈ 450,000 pCI/g

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Treatment and Recovery Facilities

DAWSON CREEK

KOTCHO

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Workover Rigs & Pipe/Pump Reconditioning

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Drinking Water Treatment Plants

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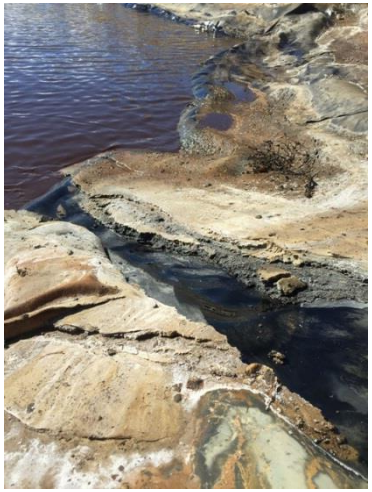
Drinking Water Treatment Plants

Potential Concerns: Radium Impacted Waste?

- External exposure
  - Gamma radiation
- Internal exposure
  - Inhalation - Low Level Radioactive Dust (LLRD)
  - Radon gas build up – tanks and pits
- Spread and tracking of Radium Sludge (clothing, pickups, equipment)
- NORM-Impacted Equipment (pumps, pipe, hoses, fire tubes, other)
- Training and Regulatory Requirements
- Transport and Licensed Disposal of NORM Waste



Analytical

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Billings, MT 59101
(406)254-7226

ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: 2016-833[redacted] SWD Pipe Scale
Pace Project No.: [redacted]

Sample: [redacted] **Pipe Scale** **Lab ID: 10338579001** Collected: 02/08/16 14:00 Received: 02/15/16 11:33 Matrix: Solid

PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis
Comments: • Sample collection dates and times were not present on the sample containers.

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Lead-210	EPA 901.1	**461.280 ± 760.140 (991.200) C:NA T:NA**	pCi/g	02/25/16 22:26	14255-04-0	
Radium-226	EPA 901.1	**22319.000 ± 3129.900 (922.400) C:NA T:NA**	pCi/g	02/25/16 22:26	13982-63-3	
Radium-228	EPA 901.1	**7672.700 ± 1020.400 (119.900) C:NA T:NA**	pCi/g	02/25/16 22:26	15262-20-1	

This is a *rare* exception from ND. COGA data does not reflect any elevated readings.

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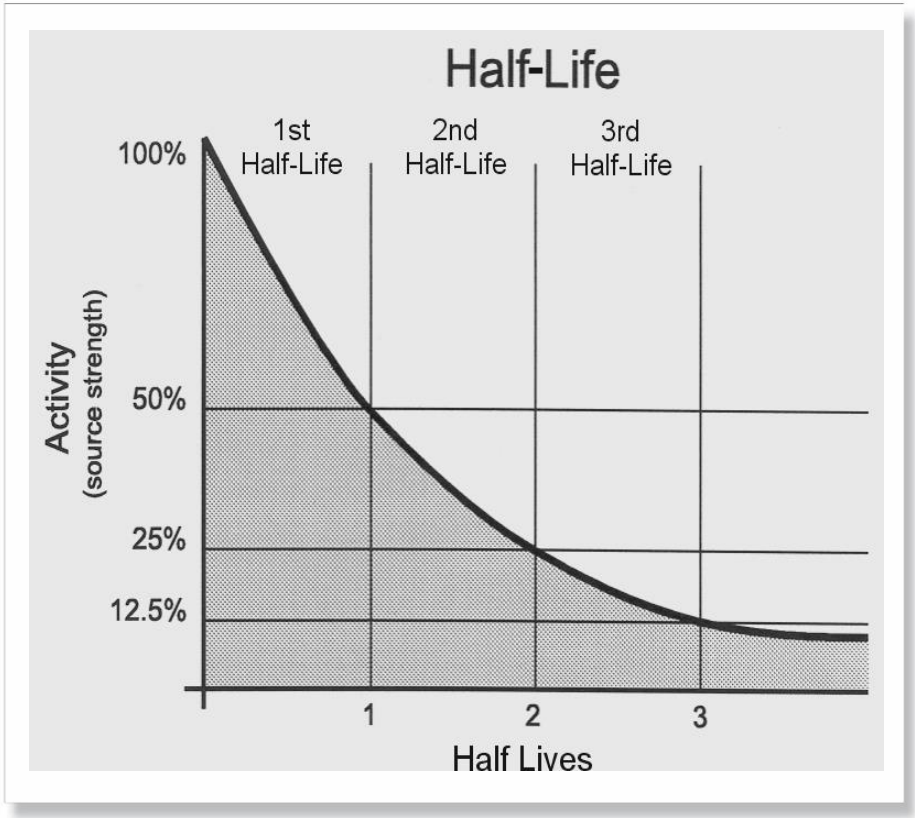
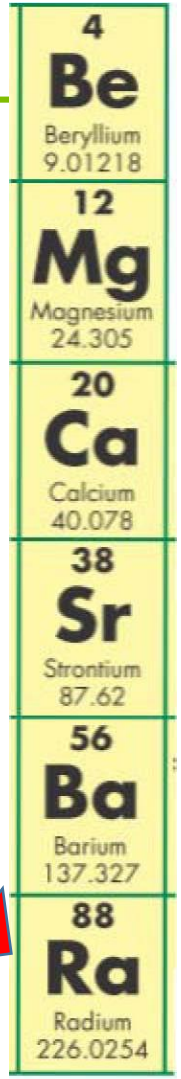
A Glance at the Physics

Two Primary Isotopes of Concern: ^{226}Ra and ^{228}Ra

- ^{228}Ra Half-Life is 5.7 years
- Radon - less than 4 days
- ^{226}Ra 1620 years

No magic wand or treatment options – the Laws of Physics apply





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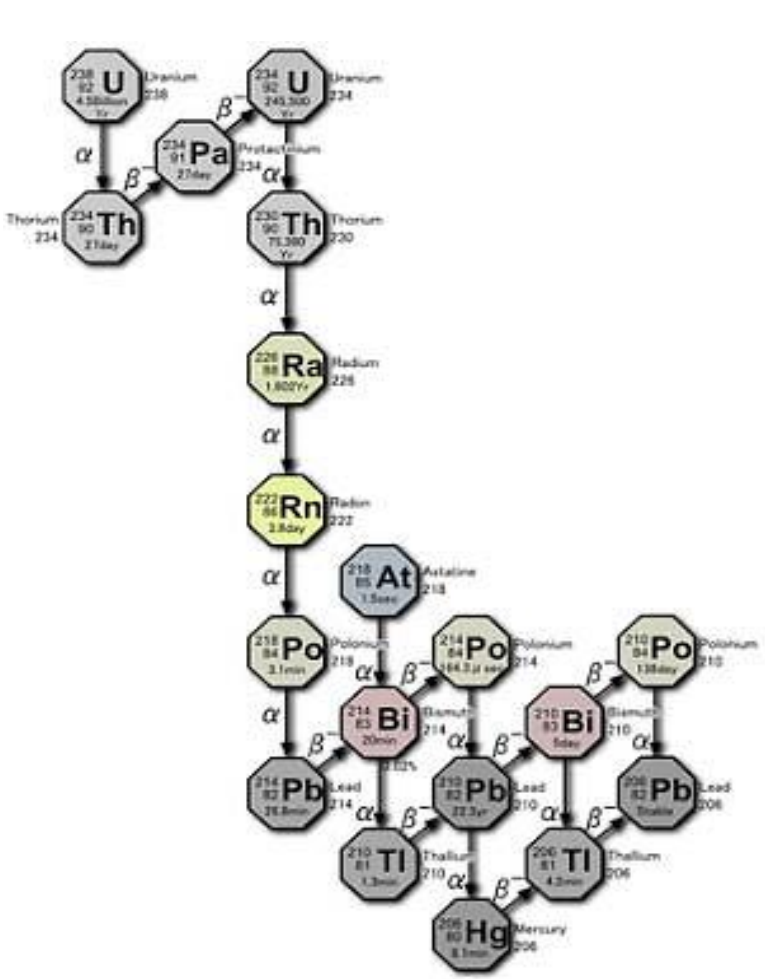
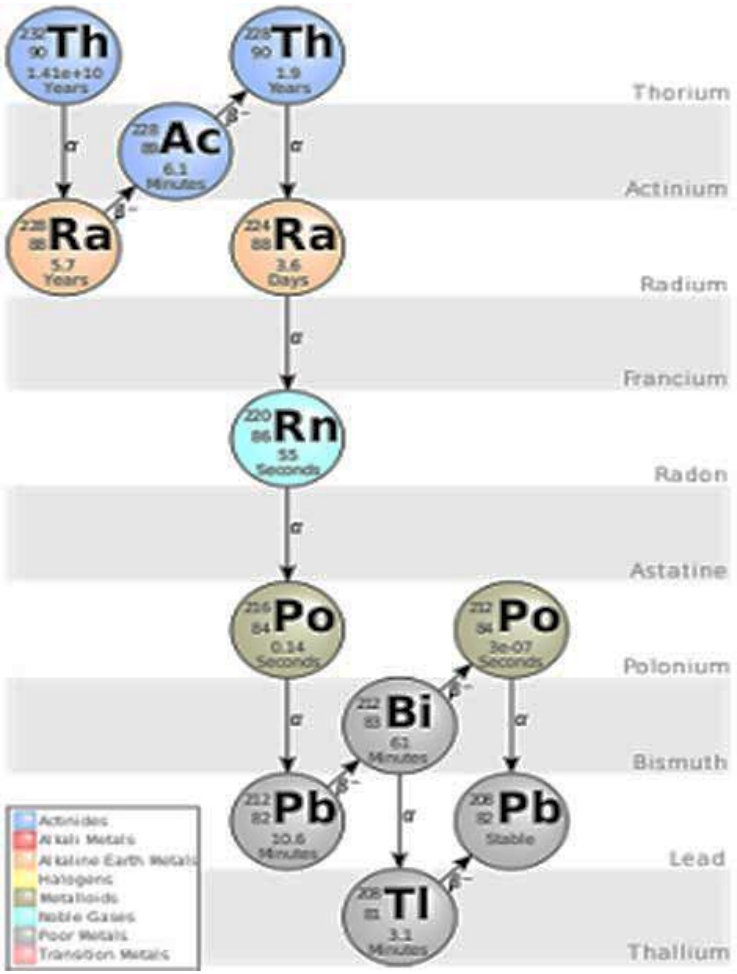
Decay Chains – The Law of Physics





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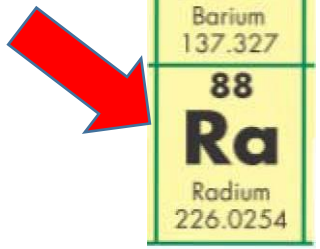
The Practical Implications

- Where Uranium exists, Radium will always be present
- Where Radium exists, Radon gas will always be present
- Natural radiation will never go away
- There is no escaping radiation in our natural environment



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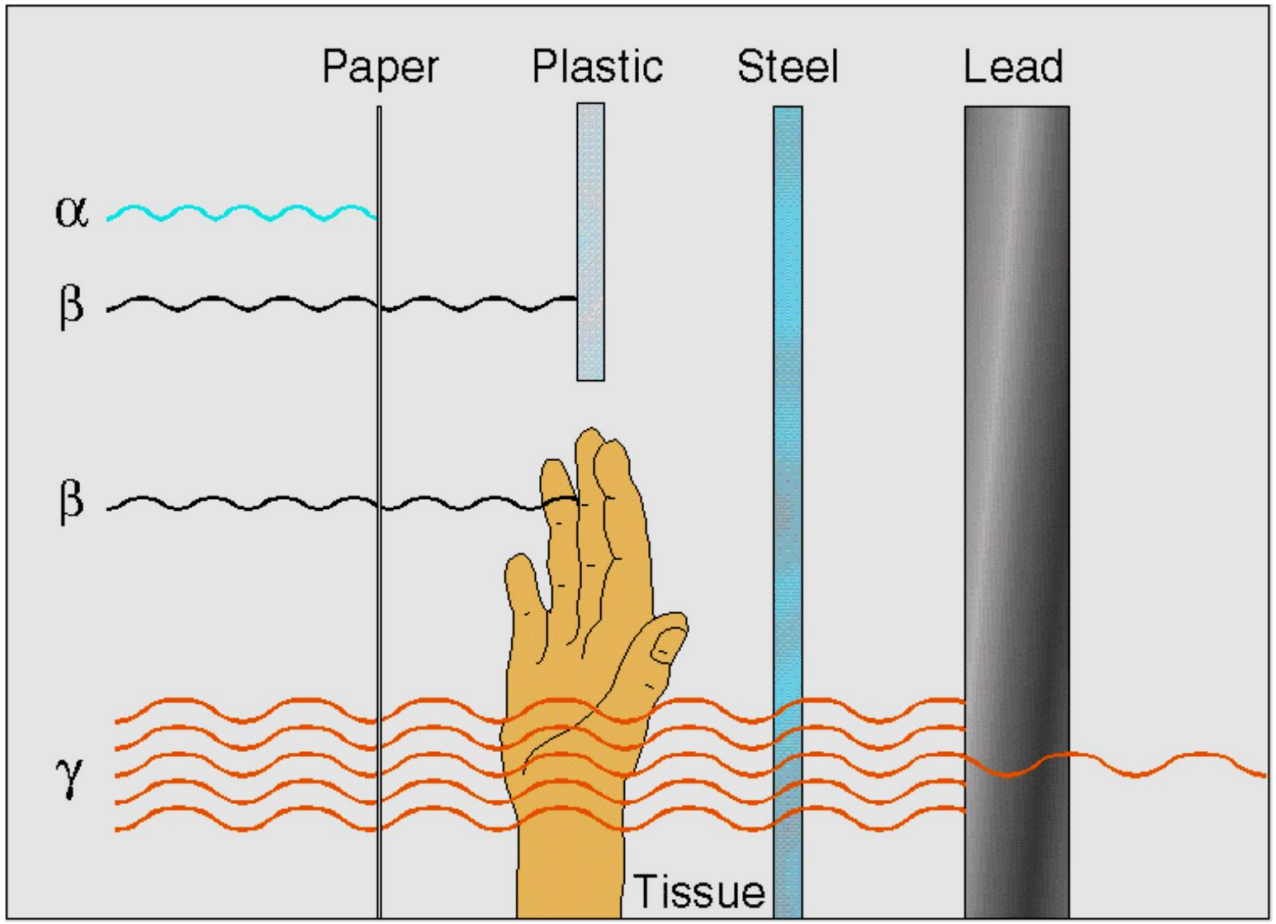
Penetration of Radiation Types



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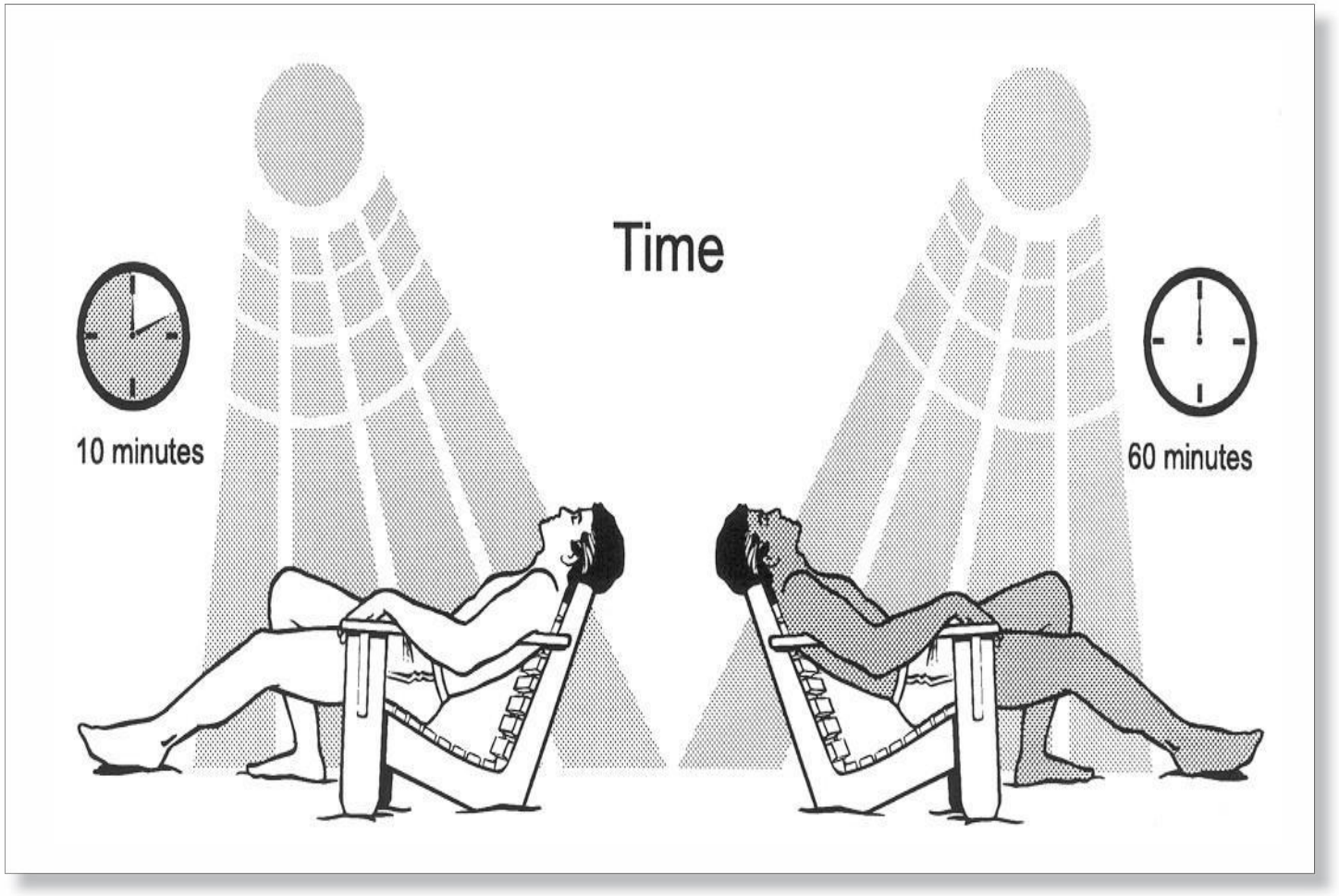
So How Do We Limit Our Exposure?



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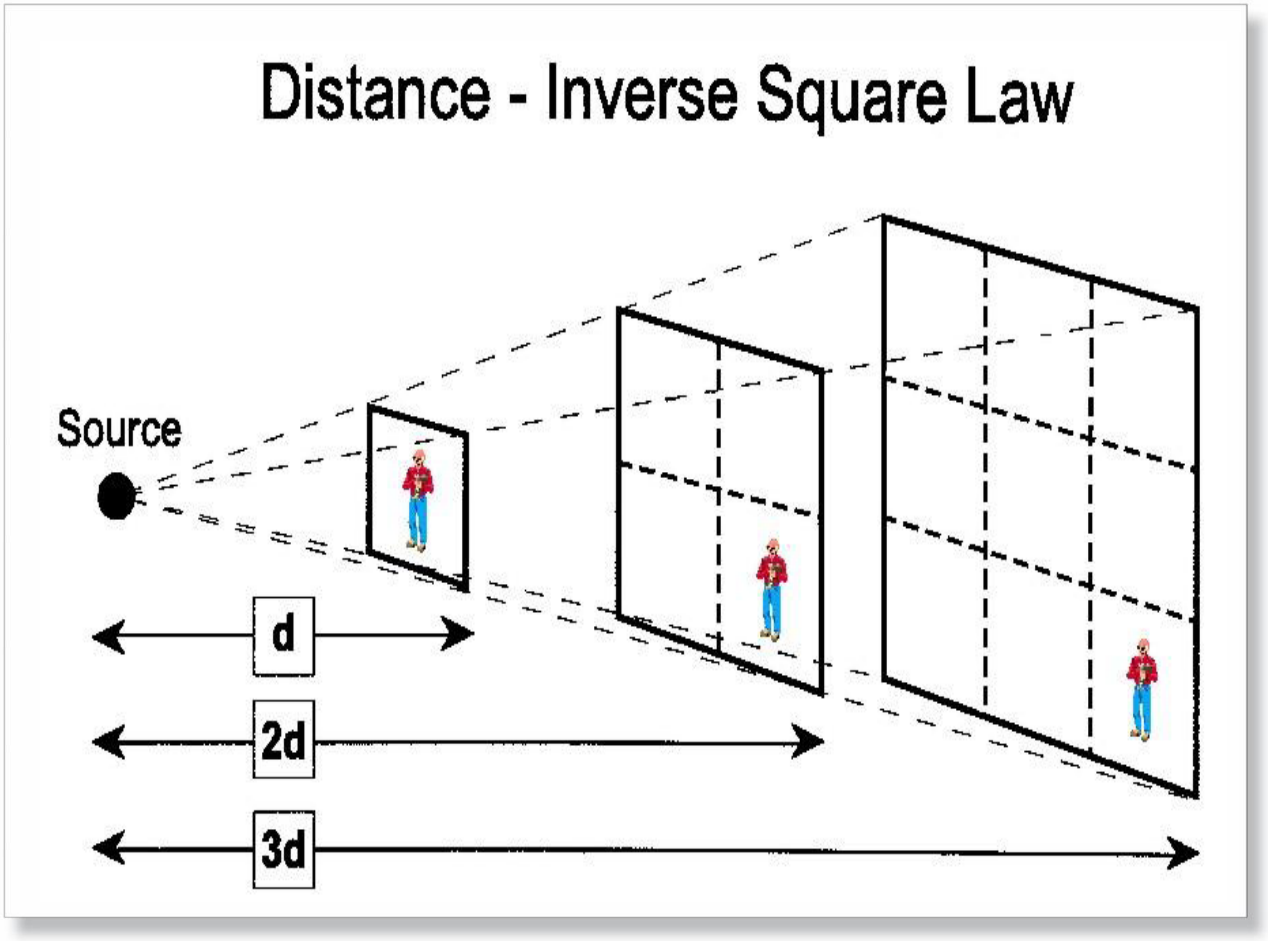
Protecting Ourselves



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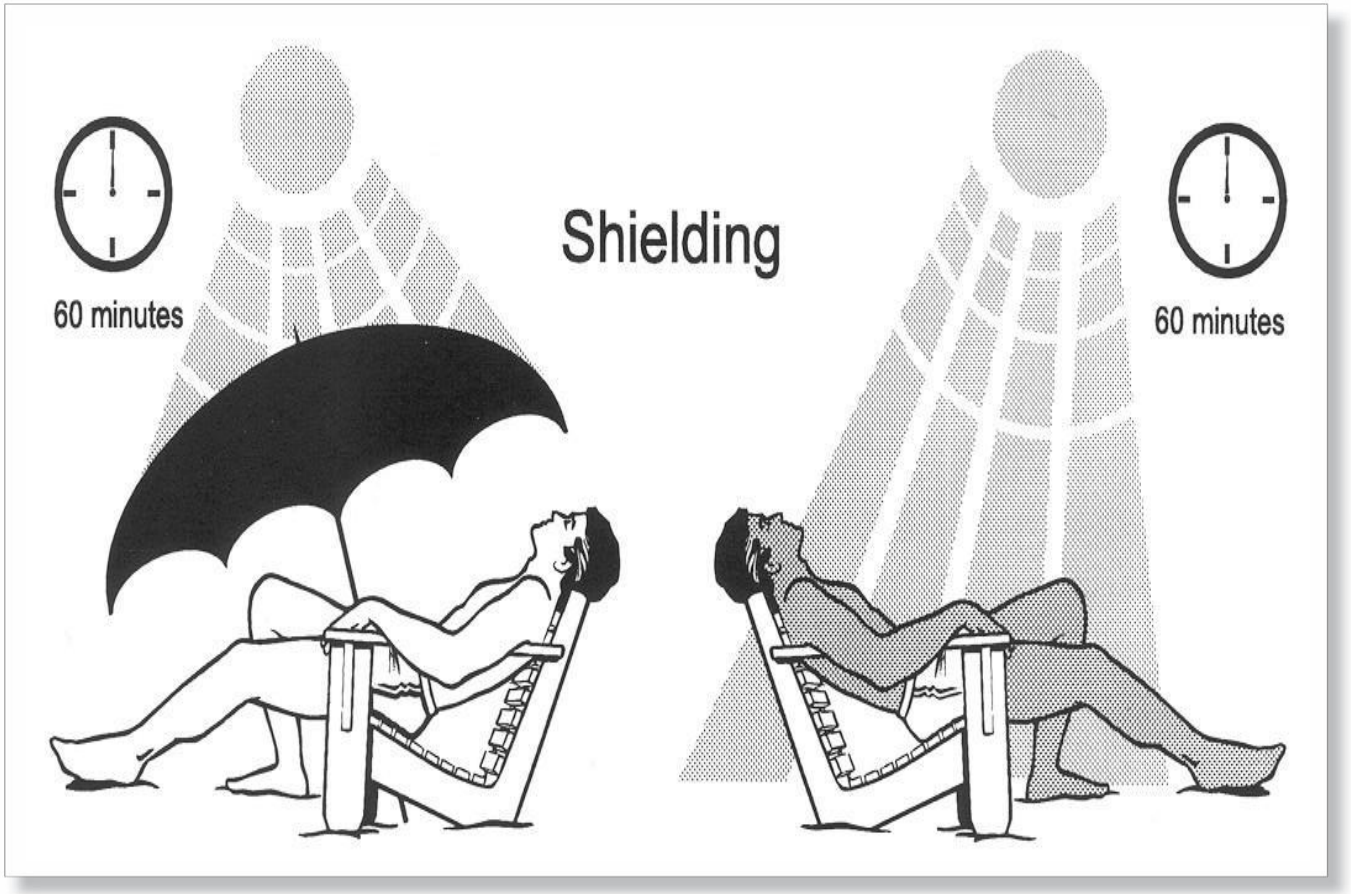
Protecting Ourselves



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Context, Context, Context

- Radiation at low levels is *not* dangerous
- The *real* threats are not where we think they are
  - Not in U.S. nuclear power plants or submarines
  - Not at most U.S. workplaces
  - Not in *most* oil and gas production – e.g. drill cuttings
  - Not in water treatment plants – e.g. backwash residuals
  - Not in U.S. landfills that accept low-level TENORM

Context, Context, Context

Areas of focus are and **should be on *higher levels***:

- Medical – including nuclear medicine, x-ray/CT/PET scans
- Industrial irradiation equipment – dog food plants, pipeline inspection, etc.
- Oil and Gas - Filtration of production water, re-manufacturing used pipe/valves, SWDs, pigging waste, radioactive tracers (at first use), and workover rigs
- Water Treatment - filtration units that focus on radionuclide removal, (though most are still at very low levels)

Protecting Ourselves

For most of us, the bigger issues are our Life Choices:

- Where we live
- How much time we spend unprotected in the sun
- If we smoke
- How much we spend time in an airplane, or hiking, or skiing
- Practicing basic hygiene and using PPE at work

What We Don't Get To Control

- Solar flare-ups
- Volcanos
- Nuclear bombs
- Family history and some illnesses

Life Choices - Cigarette Smoking

- A cigarette smoker gets 1,000 mrem/year effective dose (above background) from Polonium 210
- Smoker's effective dose = 10x annual public exposure limit (100 mrem (U.S. NRC)
- Chest x-ray = 8 mrem. Smoker = 125 chest x-rays/year !!
- Assuming 15% of population smokes, their total dose/year = 30x more than the total annual dose to all workers at the 100 nuclear power plants in U.S. + all workers at U.S. DOE nuclear installations + all crews on U.S. Navy nuclear ships[1]

See Moeller DW and Sun C, Thinking Outside the Box: Polonium 210 in Cigarettes – A Needless Source of Radiation Exposure, Health Physics News,37,4,April 2009

Banana Equivalent Dose

Bananas: A radiation hazard?

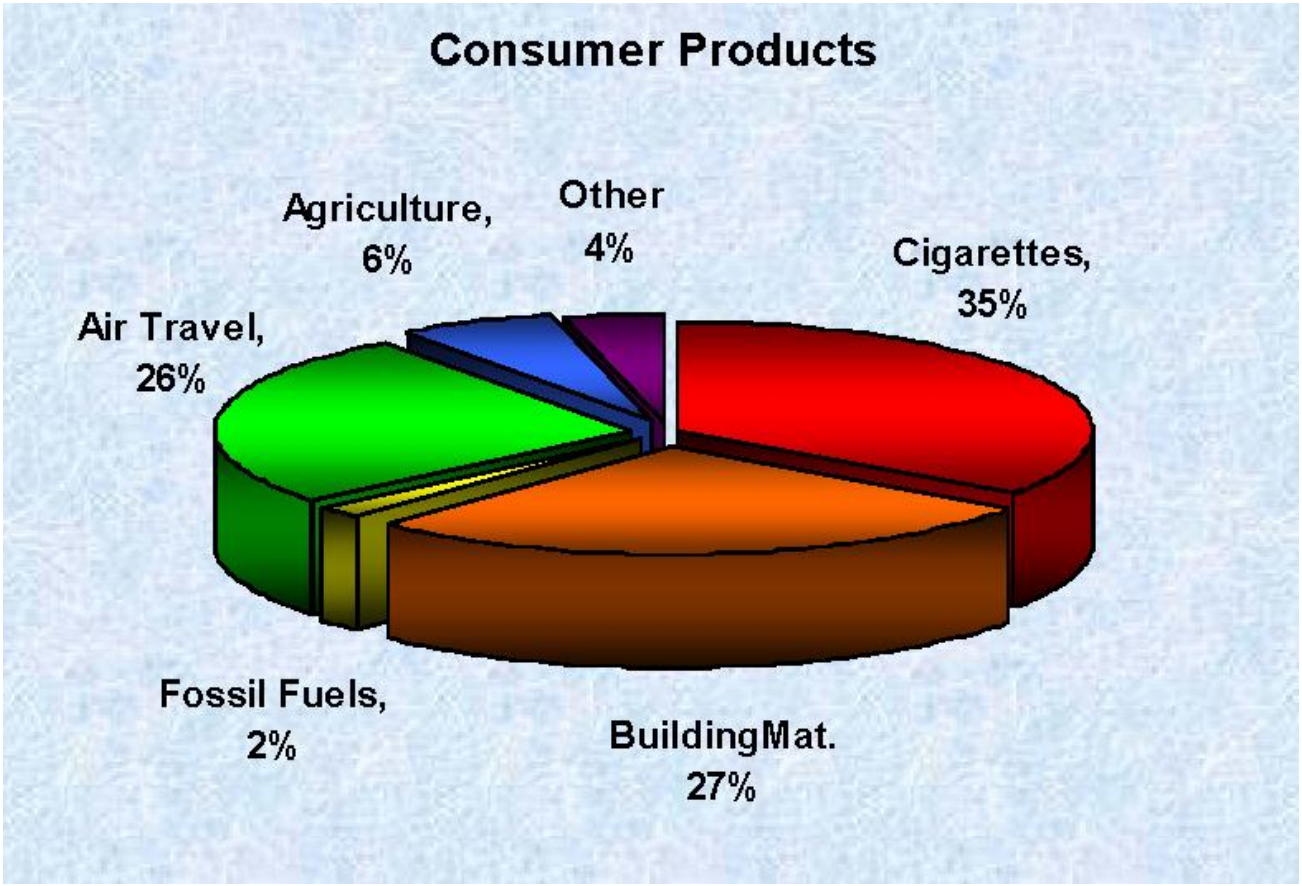
Average "K-40 Dose"
= 20 – 30 mrem/yr !

- One banana contains approximately 422 mg of potassium
- The naturally occurring radioactive isotope of potassium, K-40, has a natural occurrence of 0.0117%
- So: about 0.05 mg is radioactive or 13.3 Bq (about 400 pCi) of radioactivity per banana
- If a "bunch" = 10 bananas, that's 130 Bq (4000 pCi) of K-40 per bunch of bananas
- Your body contains about 4000 Bq of radioactive K-40 (250,000 decays every minute!)
- 5 oz of uranium ore of 0.1% grade, contains as much radioactivity from uranium as K-40 in ten bananas (60 to 80 oz)

Some Radiological Frames of Reference

- Humans are radioactive *(approximate for 150 pound person)*
  - 100,000 to 200,000 pCi ^{40}K
  - 30 pCi each U and Ra
  - 100,000 pCi ^{14}C
  - 600 pCi ^{210}Pb
- Typical annual U intake in foods (pCi)
  - Meat: 50 to 70
  - Fruit: 31 to 50
  - Potatoes: 67 to 74
  - Bakery products: 39 to 44
- Household smoke detector (americium)
  - Average of 1 million pCi

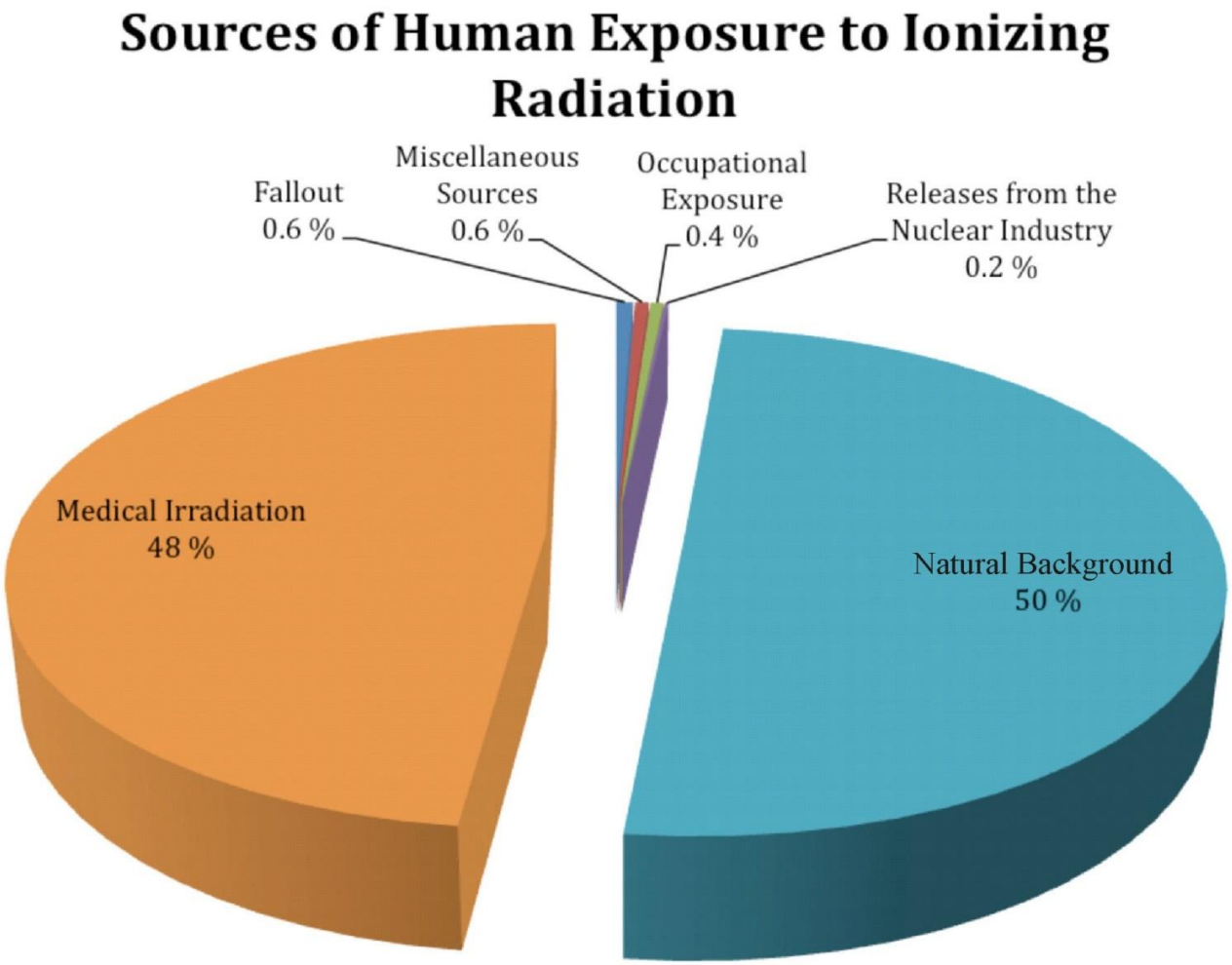
Exposure From Consumer Products Used Every Day



National Council on Radiation Protection and Measurements; NCRP Report No. 160, "Ionizing Radiation Exposure of the Population of the United States", 2006

Sources of Radiation – U.S. Averages

- **NATURAL SOURCES** – 310 millirem/year
  - Cosmic (Space) 5%
  - Terrestrial (Soil) 3%
  - Radon and Thoron 37%
  - Internal 5%
- **MANMADE SOURCES** – 310 millirem/year
  - Medical Procedures 36%
  - Nuclear Medicine 12%
  - Consumer Products 2%
  - Industrial and Occupational 0.1%



NCRP Report 160, National Council on Radiation Protection and Measurements
Ionizing Radiation Exposure of the Population of the United States, 2006

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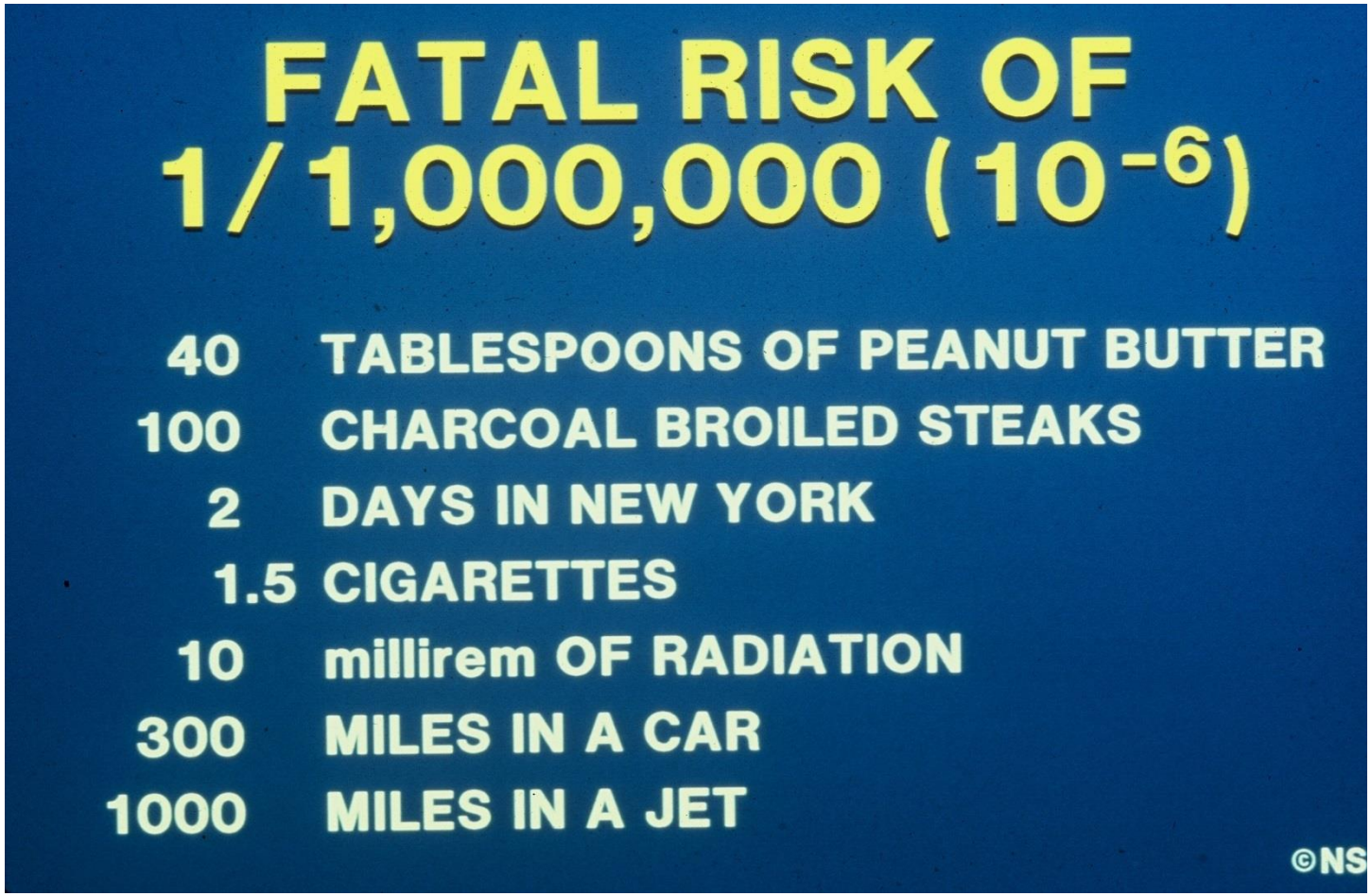
Relative Risks



Observations In Colorado

- Very modest levels in most drinking water treatment plants/systems
  - **documenting zero** – verifying safe work environment and the reasonable practices of beneficial use
  - some accumulation in systems that are designed to capture radionuclides
- Occasional, isolated, miscellaneous waste at recycling centers
- Uranium deposits/mining – part of nature and nuclear history
- We have sun and mountains – elevation and mineralization
- Most waste generated by industry in Colorado is not a major health or environmental risk

The Bottom Line - Conclusions

- Some risks are known but already well regulated
- A *few* waste streams exist that could be better monitored
- A *few* occupational risks may exist that should be licensed and monitored
- In-state disposal is not a threat to human health or the environment
- Risk-based guidance is not a good solution for industry
- Just because we can measure it doesn't make it dangerous
- Want to eliminate <u>all</u> exposure to radiation?

  - Stop breathing

  - Bury yourself in a lead-lined coffin

How Should Most People Protect Themselves?

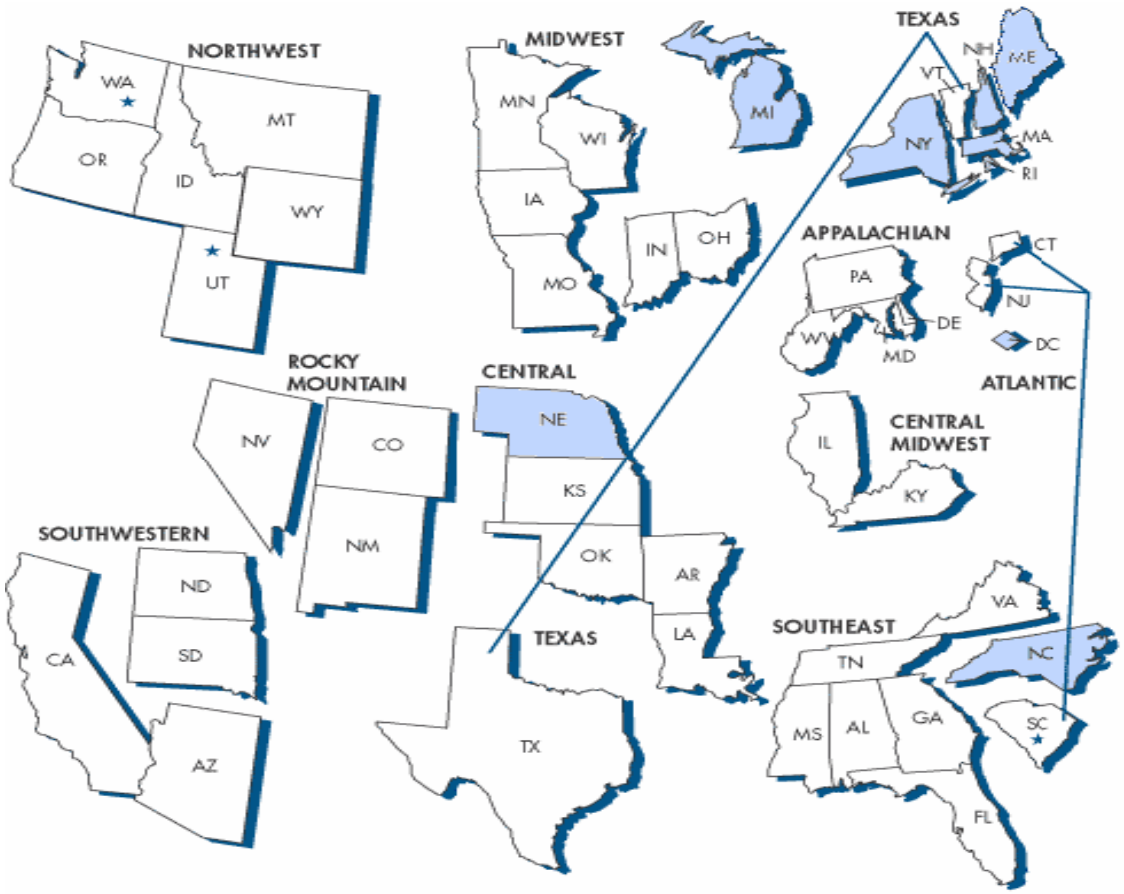
- Limit medical procedures & x-rays as much as possible
- Wear sunscreen
- Don’t smoke
- Test your home for radon
- Workers w/incidental exposure – good hygiene & PPE

Colorado Regs

- Interim Policy and Guidance for Control and Disposition of TENORM issued in February 2007
- Mostly centers on water treatment; guidance is outdated and doesn't accurately reflect available landfills in the state
- If water treatment residuals > 50 pCi/g Ra or > 15 lbs U at one time - need rad license in CO.
- ≤ 3 pCi/g above background for combined Ra-226 and -228 or Thorium

The limit is simply not justifiable based on human health and environmental risk assessments.

Compacts



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What Does Responsible Government Look Like?

1) Science-based education information – the public and industry
2) Establishing ***appropriate*** regulatory thresholds, if necessary
   - Clear, unambiguous rules and regulations founded in science & health physics
   - Easy-to-implement waste screening & acceptance criteria
3) Licensing of service providers & landfills
4) Ensuring disposal options exist – in- and out-of-state
5) Portal monitors at landfills – not to presume to screen low levels - simply to verify high level materials are not being disposed of improperly

Radiation Detection

Questions?

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